ZOOLOGY.—*On the occurrence of* Streptocephalus similis *Baird in Mexico and the United States.*

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(Received January 2, 1958)

Streptocephalus similis is a little-known fairy shrimp which has apparently been taken only twice since its description by Baird in 1852. The type lot was collected by M. Sallé on the island of St. Domingo in the West Indies; Baird's description was based upon specimens in the British Museum. Although incomplete in some respects the description was accompanied by good figures including details of the II antenna of the male.

Packard's (1883) monograph on North American phyllopods quoted the original description verbatim and was unaccompanied by figures. Daday (1910) studied a paratypic series in the collections of the Musée d'Histoire Naturelle, Paris, and presented a detailed description of the animal in his monographic revision of the Anostraca. Daday's treatment was accompanied by an excellent series of original figures including illustrations of anatomical details which had not been recorded by Baird.

A second lot of *S. similis*, collected by H. E. Crampton in Isabella, Puerto Rico, in 1915, is in the collections of the American Museum of Natural History (no. 2914). The material was identified by E. P. Creaser and served as the basis for the latter's treatment of the species in his well-known study (1930) on North American streptocephalids.

An unpublished record, consisting of a single damaged male specimen, is in the collections of the United States National Museum (no. 81601). The specimen was collected by J. W. Price in Jamaica, date unrecorded, and was identified by J. G. Mackin. As far as the writer can determine, no other collections of this species have been reported in the literature. The streptocephalids collected at Elolo in southwestern Ethiopia and recorded as *Streptocephalus similis* Baird by Cannicci (1941) were almost certainly misidentified. These African specimens lacked the definitive features of the II antenna and cercopods which are characteristic of male *S. similis*.

A number of lots of unidentified streptocephalids, taken in northeastern Mexico during the summer of 1954, were presented to the writer by the collector Ernest A. Liner. Many of these specimens proved to be *Streptocephalus similis*. During the summers of 1955, 1956, and 1957, the writer revisited many of Liner's stations and collected at other localities in Mexico and southwest Texas. A number of additional collections of this form were obtained. In view of the almost complete lack of distributional data relating to the species it seemed desirable to place these collections on record.

ACKNOWLEDGMENTS

The writer is grateful to Mr. Liner for the gift of his specimens and for providing habitat data. Fred V. Weir, of the American Museum of Natural History, and Dr. Fenner A. Chace, of the United States National Museum, made available for study and comparison the reference material deposited in the collections of their respective institutions. Dr. Robert Gordon contributed specimens and pertinent data relating to a west Texas habitat studied by himself and Alan Chaney. Dr. Folke Linder of Sweden lent the writer a number of annotated sketches of streptocephalids which he had studied in the U. S. National Museum. A productive correspondence with Dr. Ralph Dexter, Kent State University, has been of inestimable value in connection with these and other studies dealing with the Anostraca. Dr. John H. Mullahy, S.J., Loyola University, provided a translation of Daday's Latin description of the species. Andrew Arata assisted the writer in field and laboratory investigations during the summer of 1955. Field studies were made possible by a grant from the National Science Foundation (G 1738). For all the assistance noted above the writer wishes to express his sincere appreciation.

METHODS

Species of the genus *Streptocephalus* are differentiated primarily on the basis of the structure of the second antennae ("claspers"), the frontal

appendages, and the cercopods of adult males. Dissections were made and permanent mounts of these diagnostic structures prepared by a variety of methods including the techniques recommended by Mackin (1942), and by procedures involving the use of water soluble synthetic mountants.

It was found that excellent preparations could be very rapidly produced by dissecting the formalin or alcohol preserved specimens, and transferring the pertinent structures directly to polyvinyl alcohol mountant in concavity slides protected by a cover slip. Of several formulae tested, best results were obtained with that of Gray and Wess (Gray, 1952, pp. 35–36). Preparations so mounted became dry enough to handle within a few hours and little clearing of the structures occurred, a distinct advantage in the present instance since surface features were of primary importance. The customary alcohol and water soluble stains could not be employed with this technique because of the tendency of the stain to "bleed" into the mountant. However useful preparations were made by soaking the preserved specimens, with or without previous washing, in 5% silver nitrate solution and exposing them to direct sunlight for a short time. Specimens so treated were then dissected and the desired structures transferred directly to Gray and Wess's mountant. The deposition of metallic silver on the surface structures provided striking preparations for study as opaque objects by direct illumination. Even more rapid superficial deposition of silver was obtained by adding strong ammonium hydroxide to the silver-nitrate solution in which the specimens were soaked; in this case the necessity of exposing the objects to sunlight was eliminated.

REVIEW OF DIAGNOSTIC FEATURES

Of the New World streptocephalids only adult males of *S. seali* and *S. similis* are characterized by bowed cercopods, uniformly setose along the margins of the proximal portions and with short curved spines fringing the distal halves. In the case of *S. seali* these cercopods are confluent at their bases and attached to a very short but cylindrical ninth abdominal segment; in *S. similis* the cercopods are separately attached to a small lobiform ninth abdominal segment, triangular in outline. In both species the cercopods of the juvenile and immature males are uniformly setose along the margins from point of attachment to apex; it is only in fully mature specimens that the characteristic hooklike spines appear on the distal portions of these organs.

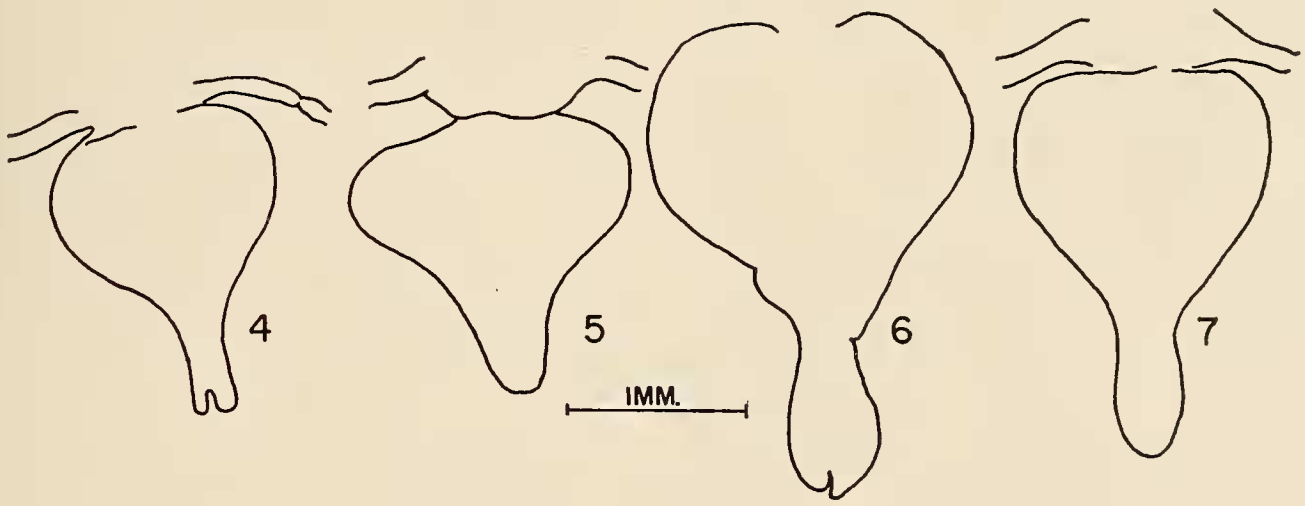
FIG. 1.—*Streptocephalus similis* Baird (Loyola collection no. 994), male, left II antenna, medial aspect. FIG. 2.—*Streptocephalus seali* Ryder (882), right "finger" (inner branch of scissors), anterior surface. FIG. 3.—*S. similis* (994), right "finger," anterior surface.

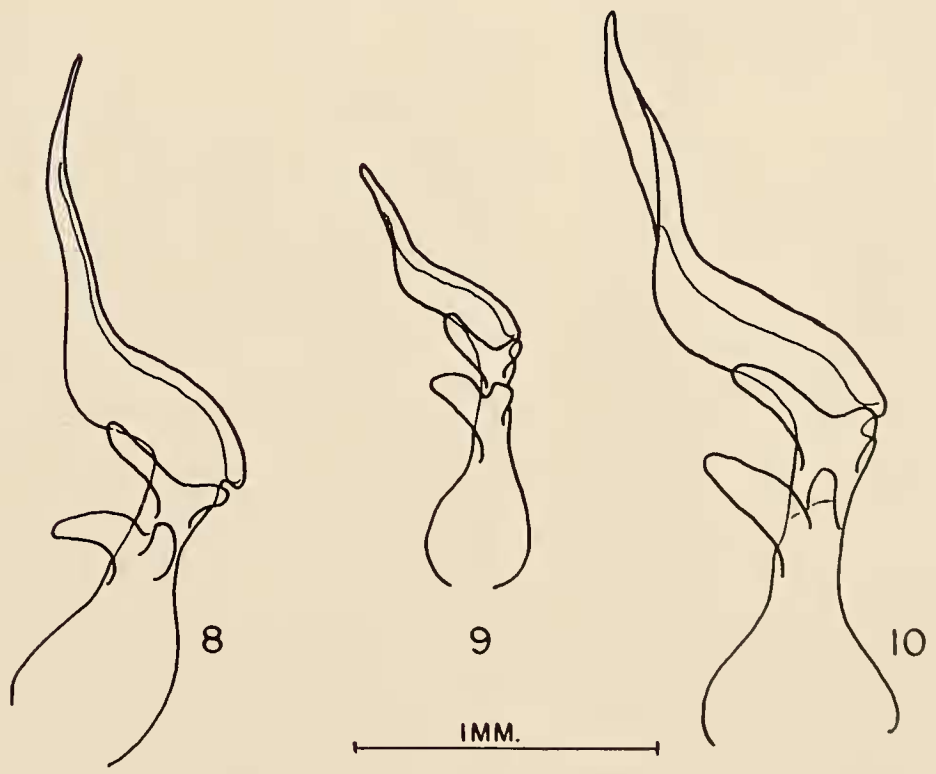
Of more diagnostic value in the separation of these two species is the character of the second or clasping antennae of the male. This second antenna of the male streptocephalid has usually been described as "3-jointed" or "triarticulate," the segments being identified respectively as a basal joint, a curved intermediate joint, and a characteristic "hand" or "scissors." Linder has shown (1941) that this interpretation is untenable; that streptocephalids have the same two joints to this limb as all Anostraca except the *Polyartemiidae*; and that the supposed second and

third joints are, in reality, simply distal outgrowths from the basal segment. The true second or apical joint is a curved, chitenous process, quite normal in form but pushed to one side by the above-mentioned distal outgrowths.

Diagnostic features of the II antenna of the male of *Streptocephalus similis* are illustrated in Fig. 1. Particular attention is directed to the proximal anterior (or dorsal) margin of the inner, shorter branch of the scissors. In *S. seali* this surface bears two processes or teeth; in *S. similis*, as is apparent from the figure, three such teeth are to be found. Creaser has stated that the middle tooth of the series is less than half the size of the adjacent teeth. Daday has given a somewhat more detailed description of these diversified processes. The anterior tooth, he reported, is large and sharp pointed; the middle, smaller and digitiform; the posterior process is characterized as large and somewhat sickle-shaped, with a bilobed anterior margin.

A comparison of the dorsal surface of the inner, shorter branch of the scissors of *S. seali* and *S. similis* is illustrated in Figs. 2 and 3. These sketches were made with the aid of a camera lucida from polyvinyl alcohol mounted preparations, the appendage in question being oriented by propping it in the desired position against slivers of glass in a concavity slide. *S. seali* (Fig. 2, from a Louisiana specimen) is characterized by the presence of two toothlike processes; the proximal one is broad at the base, sickle-shaped, and turned medially; the distal process is somewhat bilobed, with a short, rounded, laterally directed portion, and a long, slender, pointed tooth, directed medially. The comparable structures of *S. similis*, illustrated by a specimen from Dimmit County, Tex., are shown in Fig. 3. The proximal tooth in this case is likewise broad at the base, sickle-shaped, and turned medially. Lateral and slightly anterior is a much smaller process, directed vertically and confluent at its base with





Figs. 4–7.—Frontal appendage, male: 4, *S. seali* (882), Louisiana; 5, *S. similis* (A.M.N.H. no. 2914), Puerto Rico; 6, *S. similis* (985), Mexico; 7, *S. similis* (987), Texas.
Figs. 8–10.—*S. similis*, male, right "finger," anterior surface: 8, (A.M.N.H. no. 2914), Puerto Rico; 9, (982), Mexico; 10 (1017), Mexico.

the proximal tooth. The third or distal process is strongly bilobed with a short, rounded portion directed laterally and a much longer, medially directed, slender tooth.

The frontal appendage of the adult male *Streptocephalus*, variable as it frequently is, nevertheless may be a structure of some taxonomic importance. In distinguishing these two New World streptocephalids with spine-tipped cercopods the character of this appendage seems to afford a criterion of value. Ryder's (1879) original description of *S. seali* notes that the "front of the head is prolonged into a straight beak . . . it is flattened anteroposteriorly, and emarginate at its tip." Creaser refers to a "median lamina extending from forehead, branched into two bulbs at apex." The frontal appendage of a typical Louisiana specimen is illustrated as Fig. 4; the strongly bifurcate tip appears to be quite characteristic of *S. seali*.

In *S. similis*, on the other hand, the tip of the frontal appendage is rounded or only slightly divided. Baird speaks of the "beak . . . flat, rather broad, and slightly lobed at the extremity." Daday refers to a frontal process with a divided apex; his accompanying figure shows this division to be much less pronounced than is the case with typical *S. seali*. Creaser, referring to the specimens collected in Puerto Rico, describes the median lamina as "evenly rounded or slightly bilobed at apex." Fig. 5 illustrates the character of this structure in a Puerto Rican specimen (one of the lot studied by Creaser), while Figs. 6 and 7 show the extremes in variability of the frontal appendage encountered in the specimens collected in Mexico and Texas.

VARIATION IN THE FEATURES OF THE II ANTENNA

It has been noted that the proximal and middle processes, which are a feature of the dorsal surface of the inner branch of the scissors of male *S. similis*, are confluent at their bases in the Mexican and Texas specimens here considered. Baird's description of the type lot, as well as Daday's more complete treatment of material from the same collection, makes no mention of any such association of these two processes. Creaser, likewise, did not mention any confluence of these processes in specimens from Puerto Rico and the writer's examination of the latter lot verifies the supposition that these teeth, while very closely associated at their bases, nevertheless appear to originate independently from the body of the "finger" (the inner branch of the scissors).

Linder, who examined the damaged Jamaican specimen in the collections of the U. S. National Museum, expressed (personal communication) some doubt as to whether it had been correctly assigned to *S. similis*. He noted that the proximal and middle processes of the finger were "merged in the middle line." This discrepancy presents a not insurmountable difficulty, however, in view of the considerable variation noted in the positions of these two processes in the Mexican and Texas specimens.

Fig. 8 illustrates the quite complete lack of conjunction of these proximal and middle processes in a very typical specimen from the Puerto Rican lot. The third, or distal, process is strongly bilobed, a condition which Linder noted in the Jamaica specimen but which escaped mention (if it occurred) in Baird's and, later, in Daday's description of the Santa Domingo type lot. Fig. 9 shows a maximum degree of coalescence of the proximal and middle processes—a condition uniformly exhibited by a large series of specimens from Tamaulipas, Mexico. Fig. 10 (and also 3, previously cited) illustrates the nearly complete separation of these processes typical of specimens from Nuevo León, Mexico, and Dimmit County, Tex., respectively.

OTHER MORPHOLOGICAL CHARACTERS

Body size in Anostraca is not a particularly useful taxonomic criterion. The animals become sexually mature (as evidenced by the character of the penes and the II antenna in males, and the occurrence of eggs in the ovisac in females) long before maximum growth is attained. The two recorded collections of *S. similis* indicated a rather small body size for this species; Baird stated the total lengths of males and females to be five-eighths and one-half inch, respectively. Daday noted the size range for the same collection to be 13–15.5 mm for males and 14–16 mm for females. Creaser stated, with reference to the Puerto Rican collection, that "the largest specimen that I have examined is only 17 mm in length."

Total body length, from the front of the head to the tip of the cercopods, was measured in 5 to 10 randomly selected mature individuals of each sex from several of the present collections. Egg counts were also made in the case of the females,

only fully developed, shelled eggs being included in the counts. Typical results are shown in Table 1. The specimens in Lot 982 approximate in size the published collections, while Lots 994 and 1017 consist of notably larger individuals.

TABLE 1.—BODY SIZE AND EGG COUNTS FROM REPRESENTATIVE LOTS OF STREPTOCEPHALUS SIMILIS

Collection no.	Total body length in mm				Number of eggs in ovisac	
	Males		Females			
	Range	Mean	Range	Mean	Range	Mean
982	13.0–15.0	14.1	12.0–12.5	12.3	51–79	66
994	17.5–19.5	18.4	16.5–17.5	17.0	135–225	180
1017	23.0–26.0	24.4	23.0–25.0	23.7	455–541	498

Egg counts, other than serving as an indication of sexual maturity and relative age, are likewise of dubious taxonomic importance. In *S. seali* it has been shown (Moore, 1955) that egg production commences on a limited scale while the females are still far from maximum size. The process becomes increasingly active later in the life cycle, with the maximum egg production being affected not only by age and body size but also by water temperature, food supply, physiological state of the individual, and perhaps other factors as well. Nevertheless, the larger, older females usually carry considerably more eggs than the smaller individuals—a relationship which is well shown by the data in Table 1.

LOCALITIES

Fifteen lots of *S. similis* from 11 localities are listed in Table 2. A representative series from each lot has been deposited in the U. S. National Museum. Loyola University collection numbers are indicated in each case; these reference numbers have previously been used in citing the sources of the material used for figures in this paper. The number of males and females in each collection is recorded; in collections numbering several hundred specimens an aliquot of 100 only was sexed. In habitats where one or more additional species of Streptocephalus occurred along with *S. similis* the number of females of the latter species could only be approximated, the distinction being based chiefly on the relative size and shape of the ovisac. However, dependable criteria for the recognition of the females of the various species of streptocephalids have not been established and sex ratios based on such collections of mixed species are merely indicative, at best.

A striking feature of the sex ratios of these collections is the number of instances in which one sex predominated. Even if one eliminates from consideration the smaller lots (those totaling less than 50 individuals), and collections containing streptocephalids other than *S. similis*, this unequal sex ratio prevails in many cases. In the series, limited as above, the three lots with sex ratios approaching unity were noted to be immature or small mature individuals. These three collections, together with their mean lengths, were as follows: no. 983, 11.6 mm; no. 986, 11.8 mm; no. 982, 13.5 mm. The remaining lots, showing unequal sex ratios, were no. 995, 15.5 mm, with a preponderance of females over males of approximately 5 to 1; no. 994, 17.7 mm, with a preponderance of females over males of nearly 6 to 1; and no. 985, 25.2 mm, exhibiting the reverse sex ratio with a preponderance of males over females of 32 to 1.

In his study on *S. seali* the present writer (*op. cit.*) has noted that young populations of this species usually show a uniform sex ratio, with the last survivors of a brood tending to be predominantly of one sex. The data cited above would indicate a similar situation prevails in populations of *S. similis*. Unfortunately successive samplings of particular populations of the latter species throughout the course of their development are not available and the conclusion drawn must, for the present, remain tentative.

Tests were run in the field at each habitat for temperature, hydrogen ion concentration, total alkalinity, turbidity, and, occasionally, for dissolved oxygen and free carbon dioxide. Unmodified water samples were collected for later laboratory determination of chloride, and chloroform-preserved samples were taken for sulphate analysis.

The hydrogen ion concentration of all *S. similis* habitats fell within the range of pH 7.8 to pH 9.0; only two showed a pH of less than 8.2. Total alkalinity was relatively high in all cases; the range was from 54 to 260 p.p.m. with only two pools exhibiting a total alkalinity of less than 100 p.p.m. (one of these tested 97 p.p.m.). Both normal carbonates and bicarbonates contributed to these values. Turbidities were generally high, from 100 to 5000 p.p.m. as deter-

TABLE 2.—NEW LOCALITY RECORDS FOR STREPTOCEPHALUS SIMILIS

Station No.	Collector	Date	Locality	Number of males	Number of females	Associated Anostraca
977	Liner	VII-6-'54	26 miles west of Reynosa, Nuevo León, Mexico	16	17 (?)	*Thamnocephalus platyurus; Streptocephalus* sp?
979	Liner	VII-6-'54	0.5 mile southwest of Gen. Bravo, Nuevo León, Mexico	8	9	None
982	Liner	VII-13-'54	26 miles north of Valles, San Luis Potosí, Mexico	46 (aliquot of 100 specimens)	54	None
983	Liner	VII-13-'54	42 miles north of Valles, Tamaulipas, Mexico	54 (aliquot of 100 specimens)	46	None
985	Moore & Arata	VII-7-'55	Near Gen. Bravo, Nuevo León, Mexico (Liner's Sta. 979)	97 (aliquot of 100 specimens)	3	None
986	Moore & Arata	VII-7-'55	0.5 mile west of China, Nuevo León, Mexico	42 (aliquot of 100 specimens, mostly immature)	58	None (?)
994	Moore & Arata	VII-13-'55	6 miles south of Catarina, Dimmit County, Tex.	12	71	None
995	Moore & Arata	VII-14-'55	4 miles northeast of Rocksprings, Edwards County, Tex.	17 (aliquot of 100 specimens)	83	None
997	Moore & Arata	VII-15-'55	12 miles southwest of Sheffield, Terrell County, Tex.	18	6 (?)	*Streptocephalus* sp?
998	Moore & Arata	VII-15-'55	13 miles east of Sonora, Sutton County, Tex.	63	37 (?)	*Streptocephalus* sp?
1017	Moore	VI-13-'56	44 miles south of Nuevo Laredo, Nuevo León, Mexico	23	8	*Thamnocephalus platyurus*
1018	Moore	VI-18-'56	Same as Sta. 1017	10	12 (?)	*Streptocephalus* sp?
1019	Moore	VI-20-'56	Same as Sta. 997	204	22 (?)	*Streptocephalus* sp?
1071	Moore	VI-18-'57	Same as Sta. 998	23	48 (?)	*Streptocephalus* sp?
1072	Moore	VI-18-'57	14 miles north of Sonora, Schleicher County, Tex.	25	5	*Thamnocephalus platyurus*

mined by the Jackson Turbidimeter, although one productive habitat was characterized by clear water with no measurable turbidity. In these respects *S. similis* habitats did not differ appreciably from ponds in the area which contained only other species of streptocephalids.

Chlorides and sulphates were variable, from a trace to a maximum of 82 p.p.m. Cl^- and 20 p.p.m. $SO_4^=$. The higher values were found in habitats containing only *S. similis*, although one is probably not justified in concluding that this species is therefore more tolerant of these two ions than other streptocephalids since the total number of habitats studied was relatively small.

All previously recorded collections of *S. similis* have come from the West Indies. If one may assume that the species reached continental North America from the islands to the southeast then species-composition data for habitats in the northern and western portions of its present range should be of particular interest. The writer has collected extensively to the western borders of Texas, and north into the Texas-Oklahoma panhandle. The most northwesterly *S. similis* habitat known is a large, semipermanent cattle tank in Terrell County, Tex. This pond was seined by Gordon and Chaney in June 1952; Dr. Gordon provided the writer with a large

collection which included Anostraca and other phyllopods. The habitat was subsequently visited in the summers of 1955 (collection no. 997), 1956 (collection no. 1019), and 1957. The species-composition of the anostracan population, males only, is shown in Table 3.

TABLE 3.—SPECIES-COMPOSITION OF ANOSTRACA POPULATION (MALES ONLY), TERRELL COUNTY HABITAT

	VI–11–1952	VII-15-1955	VI-20-1956	VI-17-1957
Streptocephalus sp. "Type A"	549	154	98	0
Streptocephalus sp. "Type D"	22	2	2	0
Streptocephalus similis	0	18	204	0
Total	571	174	304	0

In June 1952 the Anostraca population was composed almost entirely of an undescribed streptocephalid, here designated "Type A." A few "Type D" (which may be a variety of *S. texanus*) were included, but no *S. similis* were found in the collection which numbered over 1,200 specimens, females included. Three years later, in July 1955, the same two forms were present but, in addition, 18 male *S. similis* were taken. In 1956 the proportion of *S. similis* had increased to the point where they constituted two-thirds of the male anostracans present. When last visited, in June 1957, it was found that carp minnows had been introduced into the pond and no phyllopods were present. Unless the pond dries completely sometime in the future, killing the fish, it seems unlikely that Anostraca will be taken again from this habitat. Nevertheless, the present rather circumscribed distribution of *S. similis* together with its increase in numbers from zero to a position of predominance within four years in a habitat on the border of its range would indicate that the species may be of rather recent introduction into continental North America, and that it is apparently competing successfully with the native streptocephalids.

SUMMARY

1. *Streptocephalus similis* Baird, reported only twice since 1852, is here recorded from 11 habitats in Mexico and Texas.

2. The diagnostic characters of the species as illustrated by the present collections are compared with the published descriptions and with certain museum specimens from the West Indies.

3. Sex ratios and egg counts are presented for the recent collections. In general the younger populations of small individuals exhibit a 1:1 sex ratio. Older populations of larger specimens usually showed a striking predominance of one sex over the other.

4. Certain physico-chemical factors of the habitats are summarized. None of the factors measured can be definitely correlated with the occurrence of *S. similis*.

5. The changes in the species-composition of an Anostraca habitat over a period of five years is presented as indicating support for the hypothesis that *S. similis* may be of relatively recent introduction into the North American continent.

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